Construction of a Depth Control Stand for use with the Neutron Probe (File: stand.pln).

S.R. Evett, USDA-ARS, P.O. Drawer 10, Bushland, TX 79012. srevett@cprl.ars.usda.gov

Rationale

The depth control stand allows us to reach two objectives that are essential for accurate water content readings with the neutron probe. The first objective is to ensure that the probe is at the correct depth for each reading. We take readings at the 10-cm depth and in 20-cm increments below that. Our stands (Fig. 1) slide over the access tubes and keep the gauges a constant height above the soil surface, in our case, 81.2 cm (32.4 inches) from gauge base to soil surface. We then set cable stops to give the desired depths of measurement. With this system we always get reading depths referenced to the soil surface, not to the top of the access tube. In normal field use, the user can walk through the field quite readily with gauge in one hand and stand in the other, even in tall corn.

Fig. 1. The stand in use while obtaining readings in an access tube. The stand is placed over the access tube, which keeps the stand from tipping over. The base plate is not used.

Fig. 2. The stand in use for taking a standard count. The stand is placed on a base plate that keeps it from tipping over.

The second objective is to ensure that standard counts are not influenced by soil water content or other influences. We set the stand on a base plate to take standard counts in the field away from vegetation (Fig. 2). Previous to this, we saw that standard counts varied depending on whether the soil was very wet after a heavy rain, or dry (this with the gauge case set on the soil surface and the gauge set on the case for the standard count).

A third objective, not related to accurate water contents but definitely related to accurate crop water use data, is that the use of the probe not interfere with the plants in closely planted rows. The stand is narrow enough to be placed over an access tube in a crop row with minimal plant disturbance.

Other advantages of the stands are that 1) the user can operate the gauge while standing,

avoiding the back and knee strains incurred when the gauge is set directly on top of the access tube, 2) any interference of the gauge shield with the 10-cm depth reading is eliminated, and 3) in case a user is inattentive, the gauge is more visible to machine operators when on top of the stand then when on top of an access tube. Because cable stops may slide on the cable or the insulation may move up or down the cable, it is advisable to check the positions of cable stops periodically during the measurement season.

Material List for Steel Stand for 1.5 inch probe (see below for aluminum stand)

Five steel couplers for nominal 38-mm (1.5-inch) inside diameter Schedule 40 black steel pipe.

One 70.5-cm (22-5/8-inch) length of nominal 38-mm (1.5-inch) inside diameter Schedule 40 black steel pipe.

91.5 cm (3 feet) of 2.54-cm by 0.32-cm (1 by 1/8-inch) steel strap.

One piece of 0.32-cm (1/8-inch) steel plate, 35.5 by 48.3 cm (14 by 19 inch)

One 20-cm (8-inch) length of 38 mm (1.5 inch) nominal diameter electromechanical tubing (EMT)

Construction Steps

Weld the couplers together in a stack (Fig. 3). It helps to bevel the ends of the couplers in a lathe or with a grinder. It also helps to clamp the couplers in a v-shaped holder for welding.

Thread one end of the 38-mm pipe to fit the coupler (NPT).

Use a lathe or grinder to reduce the outside diameter of the other end of the 70.5-cm length of pipe to 4.5 cm (1-49/64 inch) along a 3.8-cm (1-1/2-inch) length from the end (Fig. 4).

Fig. 4.

Fig. 3. View of completed stand showing pipe couplers that were welded together.

Cut the steel strap into two 43-cm (17 inch) lengths. Bend in three places as shown in Fig. 5.

Cut one 35.5 by 35.5-cm (14 by 14 inch) square piece from the steel plate, and bend the corners down to produce 4.5-cm (1-3/4 inch) long pointed legs as shown in Fig. 6.

Weld the 20-cm piece of EMT perpendicular to the center of the square piece of steel plate and on the side away from the legs (Fig. 6).

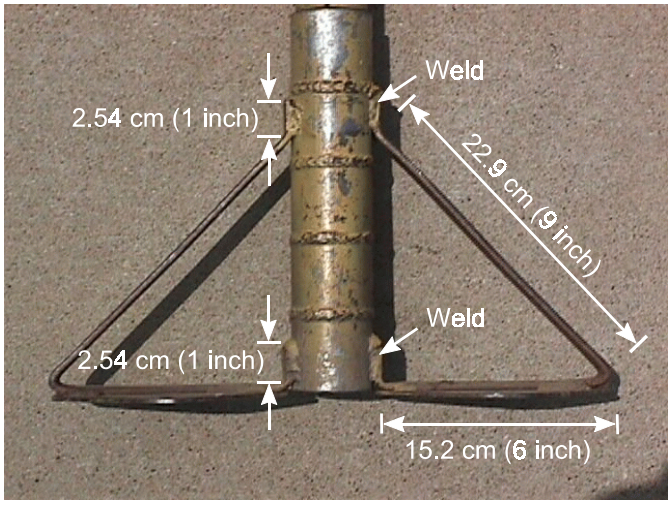


Fig. 5. Strap iron bends and lengths between them.

Fig. 6. Base plate showing two of the four pointed feet created by turning down the corners of the plate.

Fig. 7. View from the bottom of the diamond-shaped feet. The points of the diamonds were rounded in a grinder after they were cut.

Cut the remaining plate to produce two diamond-shaped pieces with distance between the points of about 15.6 cm and 14 cm (6-1/8 and 5-1/2 inch). Round the points with a grinder (Fig. 7).

Clamp one bent piece of strap to a welding bench and place the welded stack of couplers perpendicular to the bench and against the strap. Clamp as necessary to have the bottom of the strap firmly against the bench top and both ends firmly against the stack of couplers. Weld in place (see Fig. 5 for weld points). Repeat with the other bent piece of strap on the other side of the stack of couplers (180 degrees from the first attachment). Weld the diamond-shaped plates, one each, to the bottoms of the strap pieces with the long axis of the diamond coincident with the axis of the strap (Fig. 8).

Screw the pipe into the top of the stack of couplers, continuing to screw in until the height of the stand is 81.2 cm (32.4 inch) above the surface upon which it stands. Tack weld in place.

Dress all edges to remove burrs and sharp edges. Prime and paint a bright orange to aid visibility by machine operators.

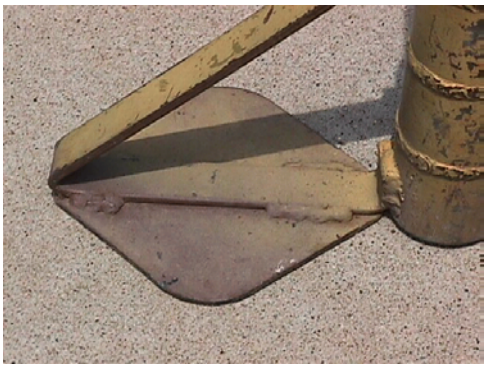


Fig. 8. Detail of welding the diamond-shaped plate to the strap iron to form the feet of the stand.

Notes

Five stacked couplers allows room for about 23 cm (9 inches) of access tube extending above the soil surface. If more space is desired, add additional couplers to the stack and reduce the length of the pipe accordingly.

Set access tubes to extend 10 to 20 cm above the soil surface. The exact height is not critical - just make sure that there is enough access tube above the surface to prevent the stand from tipping over. If there is not enough access tube to prevent tipping, the gauge and stand can be held in place by the user.

The user should step away from the gauge (one or

two steps) when taking a shallow reading (say at 10-cm depth), and when taking a standard count (at least 3 m away), to avoid receiving unnecessary radiation and to avoid influencing the readings.

The stand described is for a 3.8-cm (1.5-inch) diameter probe. For a 5.1-cm (2-inch) diameter probe, use nominal 5.1-cm inside diameter Schedule 40 pipe and couplers. Consider adding a handle to one side of the pipe because the 5.1-cm pipe is difficult for some to grasp. Consider using aluminum because the stand for a 5.1-cm probe is much heavier.

ALUMINUM STANDS

The stands whose construction is described below are intended for use with access tubes made of thin-wall electromechanical tubing (EMT), otherwise known as electrical conduit. They will also work with thin-wall PVC tubing. By "thin-wall" we mean approx. schedule 10 in the U.S.

Material List for Aluminum Stand for 1.5 inch probe and 1.5 inch EMT access tubing

One 57.0 cm (22.44 inch) length of 4.445-cm (1.750-inch) outside diameter by 0.147-cm (0.058-inch) wall thickness 6063-T832 drawn aluminum tubing
One 10.0 cm (3.94 inch) length of 4.763-cm (1.875-inch) outside diameter by 0.147-cm (0.058-inch) wall thickness 6063-T832 drawn aluminum tubing[1]
One 34.2 cm (13.78 inch) length of 5.080-cm (2.000-inch) outside diameter by 0.147-cm (0.058-inch) wall thickness 6063-T832 drawn aluminum tubing
91.5 cm (3 feet) of 2.54-cm by 0.32-cm (1 by 1/8-inch) aluminum strap
One piece of 0.32-cm (1/8-inch) aluminum plate, 12.1 by 27.9 cm (4-3/4 by 11 inch)
Six 1.27-cm (½-inch) #10 wafer top screws
Six 1.27-cm (½-inch) #10 flat-head screws
Ten #10 lock nuts with nylon inserts
Six 1.27-cm (½-inch) #8 by 32 machine screws
Fluxless aluminum brazing rod, metal fluxless II, Nutech, Albuquerques, NM

Material list for Aluminum Stand for 1.5 inch probe and 2 inch EMT access tubing

One 57.0 cm (22.44 inch) length of 4.445-cm (1.750-inch) outside diameter by 0.147-cm (0.058-inch) wall thickness 6063-T832 drawn aluminum tubing
One 10.0 cm (3.94 inch) length of 4.763-cm (1.875-inch) outside diameter by 0.147-cm (0.058-inch) wall thickness 6063-T832 drawn aluminum tubing
One 10.0 cm (3.93 inch) length of 5.080-cm (2.000-inch) outside diameter by 0.147-cm (0.058-inch) wall thickness 6063-T832 drawn aluminum tubing
Two 10-cm (3.93 inch) lengths of 5.398-cm (2.125-inch) outside diameter by 0.147-cm

[1]The mention of trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by USDA-Agricultural Research Service. Aluminum tubing of these diameters may be obtained from Texas Towers, 1108 Summit Avenue, Suite #4, Plano, TX 75074, 800-272-3467, www.texastowers.com.

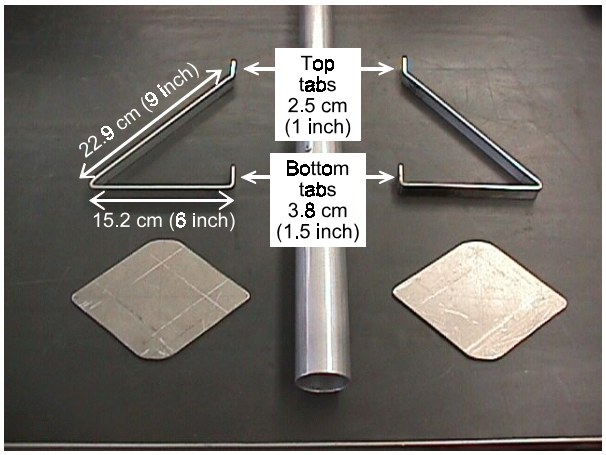


Fig. 9. Bent aluminum strap pieces and diamond-shaped pieces of aluminum plate shown with the cut tubing.

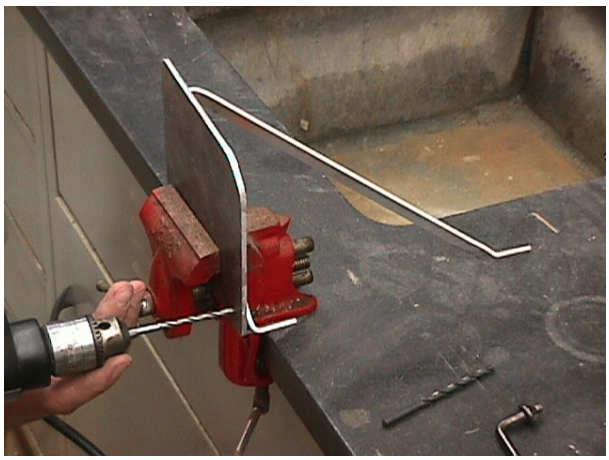


Fig. 10. Drilling the diamond-shape Al plate and strap. After drilling to accept the #10 screws, the hole is countersunk.

(0.058-inch) wall thickness 6063-T832 drawn aluminum tubing. Split one piece down one side with a hacksaw.

One 34.2 cm (13.78 inch) length of 6.35-cm (2.50-inch) outside diameter by 0.305-cm (0.120-inch) wall thickness 6061-T6 extruded aluminum tubing

Aluminum strap and plate, fasteners, and brazing rod as above

Construction Steps - Aluminum Stand

Cut the aluminum strap into two 44.5-cm (17.5 inch) lengths. Bend in three places as shown in Fig. 9, using heat to prevent cracking (propane or acetylene torch).

Cut the plate to produce two diamond-shaped pieces with distance between the points of about 18.4 cm and 16.2 cm (7-1/4 and 6-3/8 inch). Round the points of the diamonds with a grinder to produce the shapes shown in Fig. 9.

Using flat-head screws, fasten the diamond-shaped plates, one each, to the bottoms of the strap pieces with the long axis of the diamond coincident with the axis of the strap (Fig. 10). Counter-sink the bottom sides of the plates so that the flat-head screws are flush with the surface. The assembled bent straps and plates are called the feet. Using screws allows the plates to be replaced with smaller plates if the stand is used in a closely planted crop.

Insert the 10-cm aluminum tube(s) inside the 34.2-cm tube so that the ends meet at one end. If making the stand for 2-inch access tubing, expand the split 10-cm length of 5.398-cm tubing to fit over the other piece of the same size. Drill a hole through the tubes near the top using a #29 bit. Leaving the bit in place, slide the 57-cm tube inside the top end. Measure the height of the assembled tubes and slide the 57-cm tube up or down until the height is 81.2 cm. Preventing the tubes from sliding, drill through the hole into the 57-cm tube. Tap the hole for a #8 machine screw and insert the screw. Drill and tap through all three tubes in five to seven more places, placing screws 2-cm from the top(s) of the 10-cm tube(s) and 2-cm from the bottom(s). Fasten with #8 machine screws. The machine screws may have to be shortened so that they do not protrude into the inside of the stand. Use a locking compound on the screw threads during final assembly.

Connect the feet to the tubing using screws or by welding. If using screws, drill the top and bottom tabs of the bent Al strap to accept #10 screws (Fig. 9, two screws through the bottom tab). Place the feet on opposite sides of the 34.2-cm piece of tubing and mark the tubing for drilling (Fig. 11). Drill the tubing with a 0.8-cm (5/16-inch) bit. Assemble the bottom tabs of the feet to the tubing using the wafer top screws and lock nuts (Fig. 12), or weld. The next steps are easier with two persons. Place the assemblage on a table with the tubing perpendicular to the table top and the feet held flat against the table top. Press the top tab of the bent Al strap against the tubing and drill through the hole in the tab into the tubing, or weld in place. Repeat for the other foot. If using screws, enlarge the holes in the tubing using a 0.8-cm (5/16-inch) bit. Drill another hole in the tubing at 90 degrees from the position of the last two holes. Fasten the top tabs of the feet to the tubing using wafer top screws and lock nuts. Use a right-angle bend screwdriver passed through the third hole in the tube to hold the head of the screw while tightening the lock nuts (Fig. 13).

The assembled stand is shown in Fig. 14. If aluminum welding is available (e.g. Nu-Tech aluminum brazing rod), many of the screw fastenings may be replaced by welds as were used for the steel stand.

Dress all edges to remove burrs and sharp edges. Prime and paint a bright orange to aid visibility by machine operators.

Details and dimensions relevant to placing cable stops to measure at specified depths using the depth control stand are given in Fig. 15.

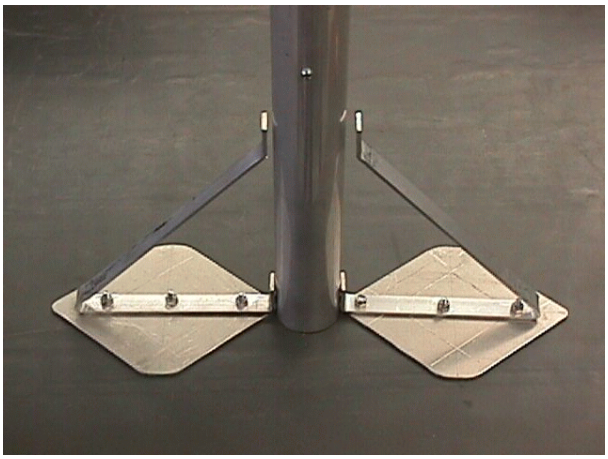


Fig. 11. Aluminum tube set perpendicular to the table top with the two feet positioned against it on opposite sides so that marks for drill holes can be made through the holes already drilled in the bottom tabs of the feet.

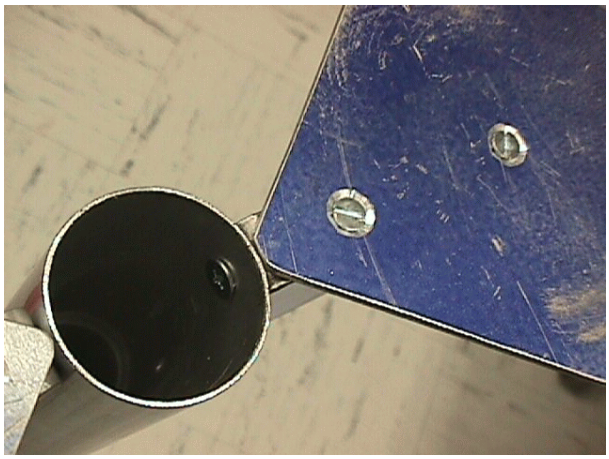


Fig. 12. Detail showing the head of one of the wafer top screws that fasten the bottom tab of one foot to the aluminum tube. The wafer top fits into the oversize (0.8-cm) hole so that it does not prevent the access tube from fitting inside the stand. Use two screws, one above the other, to provide a rigid joint.

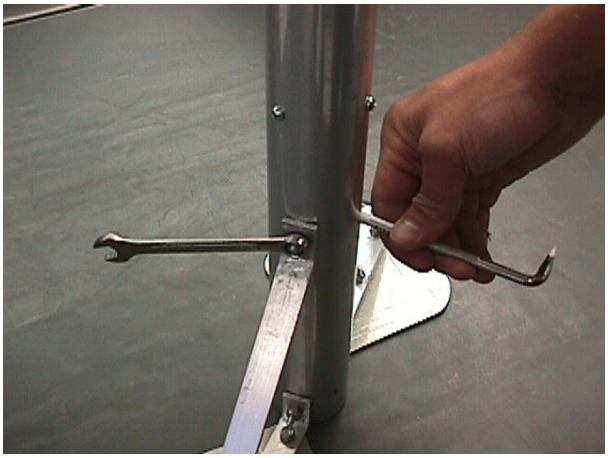


Fig. 13. The right angle bend screwdriver is inserted through the third hole in the tube in order to prevent the wafer head screw from turning as the lock nut is tightened.

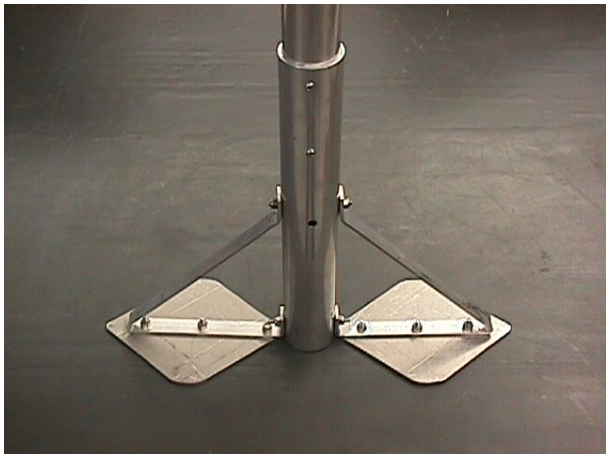
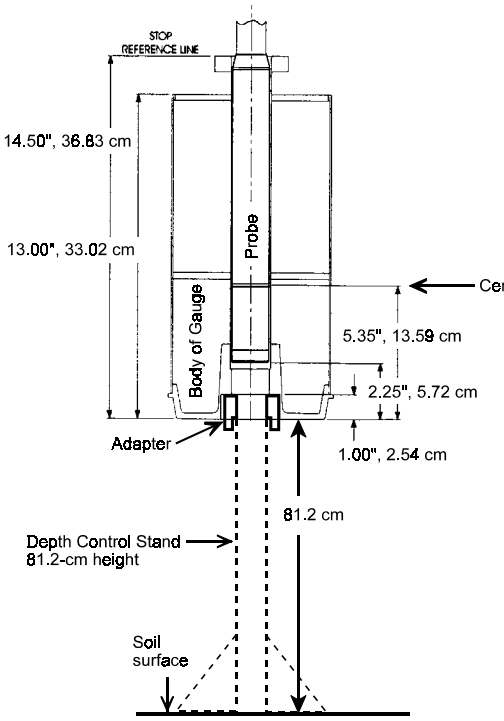


Fig. 14. The assembled aluminum depth control stand. The top is not shown.



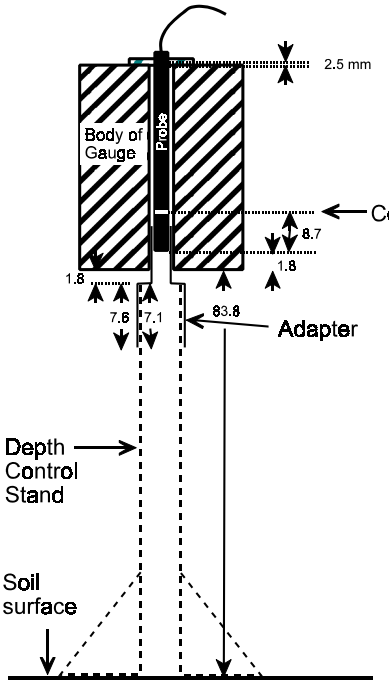
Schematic of Campbell Pacific Nuclear Model 503DR Nuclear Moisture Gauge with dimensions relevant to placement of cable stops so that the center of measurement of the probe will be placed at specified depths below the soil surface when a depth control stand is used.

Dimensions in cm unless noted. Drawing not to scale.

A

The depth control stand is 81.2-cm in height. The inside lip of the adapter is at the same elevation as the bottom of the gauge body. This is the lip that rests on top of the depth control stand. So, the bottom of the gauge body is 81.2 cm above the soil surface. The center of measurement is 13.59 cm above the bottom of the gauge body when the probe is locked in the shield. To place the center of measurement at 10-cm depth, place a cable stop at 81.2 + 13.59 + 10 = 104.8 cm above the top of the stop reference plate. The top of the cable connector is 6.5 cm above the top of the reference plate. To place the center of measurement at 10-cm depth, put a cable stop at 81.2 + 13.59 + 10 - 6.5 = 98.3 cm above the top of the connector.

To read in the center of an 85-cm tall barrel with an access tube protruding 30.4 cm above its top, place a cable stop at 13.59 + 30.4 + 42.5 = 86.5 cm above the reference plate. The top of the cable connector is 6.5 cm above the top of the reference plate. To read at the center of the barrel, place the cable stop at 13.59 + 30.4 + 42.5 - 6.5 = 80.0 cm above the top of the connector.



Schematic of Troxler Model 4300 Nuclear Moisture Gauge with dimensions relevant to placement of cable stops so that the center of measurement of the probe will be placed at specified depths below the soil surface when a depth control stand is used.

Dimensions in cm unless noted. Drawing not to scale.

B

The cable stop rests on a shelf that is 2.5 mm above the top of the gauge.

The depth control stand is 81.2-cm in height. The adapter is 7.6 - 7.1 = 0.5 cm thick above the top of the stand. There is 1.8 cm of space between the top of the adapter and the bottom of the gauge body. So, the bottom of the gauge body is 81.2 + 0.5 + 1.8 = 83.5 cm above the soil surface. The center of measurement is 8.7 + 1.8 = 10.5 cm above the bottom of the gauge body when the probe is locked in the shield. To place the center of measurement at 10-cm depth, place a cable stop at 83.5 + 10.5 + 10 +0.25 = 104.3 cm above the top of the gauge.

The top of the cable connector is 4.3 cm above the top of the gauge. When measuring from the top of the cable connector, place the cable stop at 83.5 + 10 + 10.5 + 0.25 - 4.3 = 100.0 cm above the top of the connector in order to place the center of measurement at 10 cm below the soil surface.

Fig. 15. Drawings showing dimensions relevant for placing cable stops on cables to achieve accurate depth placement of the probe center of measurement for a Campbell Pacific Nuclear Model 503DR gauge (A), and a Troxler Model 4300 gauge (B).